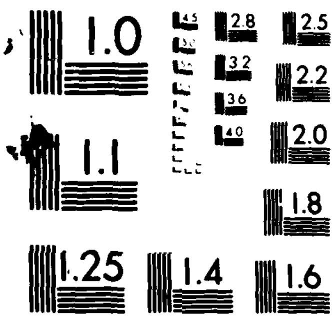
AD-A112 671 MASSACHUSETTS INST OF TECH CAMBRIDGE DEPT OF EARTH A--ETC F/G 20/11
LABORATORY AND THEORETICAL STUDIES PERTAINING TO EARTHQUAKE HAZ--ETC(U)
MAY 76 W F BRACE USGS-14-08-0001-14551

UNCLASSIFIED NL

1 of 1

END
DATE
FILMED
4 82
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

AD A112671

LABORATORY AND THEORETICAL STUDIES PERTAINING TO EARTHQUAKE HAZARDS REDUCTION

by

W.F. Brace, Principal Investigator

Department of Earth and Planetary Sciences
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

SEMI-ANNUAL TECHNICAL REPORT NO.4

for the period

1 December 1975 to 31 May 1976

Sponsored by the
U.S. Geological Survey
Contract No.14-08-0001-14551

Effective Date of Contract: June 1, 1974

Expiration Date of Contract: September 30 1976

Amount of Contract: $104,280

The views and conclusions contained in this document are those of the author and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

INTRODUCTION

During the preceding half-year we have made limited progress in several aspects of our program. We review below progress of all items in our original Statement of Work. We enclose copies of three papers published or accepted for publication during the report period, based on studies completed under this contract.

PROGRESS

(1) High Temperature Strain Measurements

We are continuing our calibration using instrumented samples of materials of known physical properties, like Armco iron, quartz, and aluminum, in an attempt to sort out the effects of pressure and temperature on the indicated strains. This work is going slowly, but needs to be done before our techniques can be applied with any confidence to the measurement of stress at pressure and temperature. A particular difficulty seems to be lack of reproducibility from one gauge to the next. One source may be in the small size of gauge relative to the sample grain size, and we are currently trying to locate larger gauges. We anticipate that these problems will be solved and that some new measurements will be available in the near future.

(2) SEM Studies of Stress-Induced Cracks

(a) As noted in our last Quarterly Report, we encountered a major problem in our SEM study of dilatant microcracks. Our plan had been to prepare pre-stressed and thinned samples which

would then be loaded and viewed under stress in the SEM (Figure 1). We arranged to use a special loading frame available to us at the Civil Engineering Research Laboratory in Champaign, Illinois. Some excellent work was described last year by members of this laboratory, and we were confident that we would for the first time be able to follow the changes in crack aspect ratio and length under stress flow. During our visit there in January, it became clear that the microscope was not functioning properly. A key technician had taken a job elsewhere, and neither we nor the remaining people at CERL were able to make the facility operational. This aspect of our work, therefore, has had to be put aside until another loading frame can either be located or fabricated. After some search at MIT, we found an electron microscope in which we should be able to continue the study. Some design and construction of adapting accessories is necessary, and these have been fabricated. We plan to use the samples already prepared, and should shortly begin testing in the microscope. It is not yet known whether we will be able to reach sufficiently high stress to change crack geometry, but we are hopeful that some progress will be possible.

(b) We have continued our detailed observation of the patterns of stress cracks near peak stress in Westerly granite. One of the new developments has been the observation of crack geometry in its relation to buckling. At high stress, cracks often run parallel to one another, forming slender columns. It has been suggested that the buckling of these columns ultimately causes fracture and faulting - in other words, that the buckling is

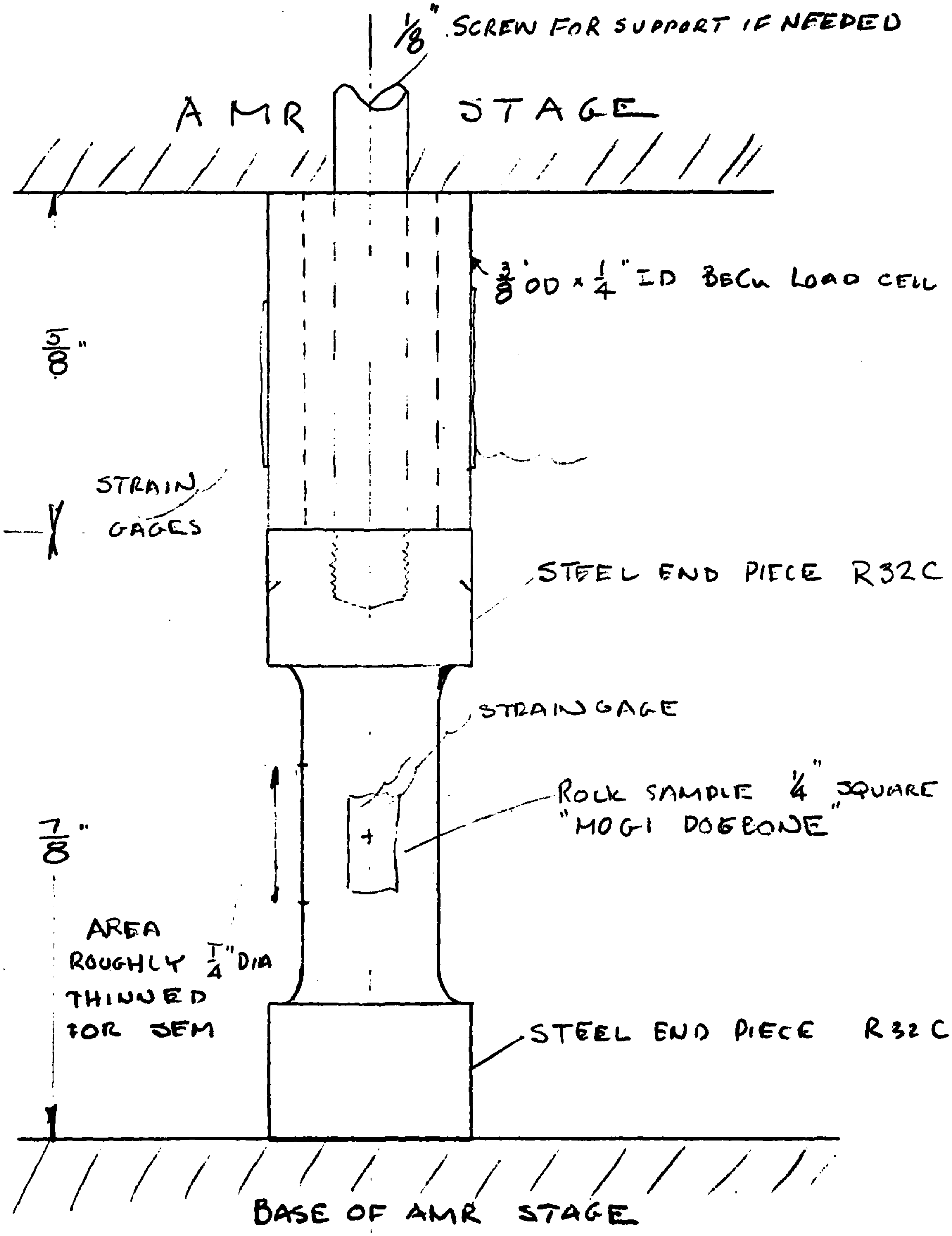


FIG 1

ROCK SAMPLE ARRANGEMENT FOR SEM COMPRESSION STAGE

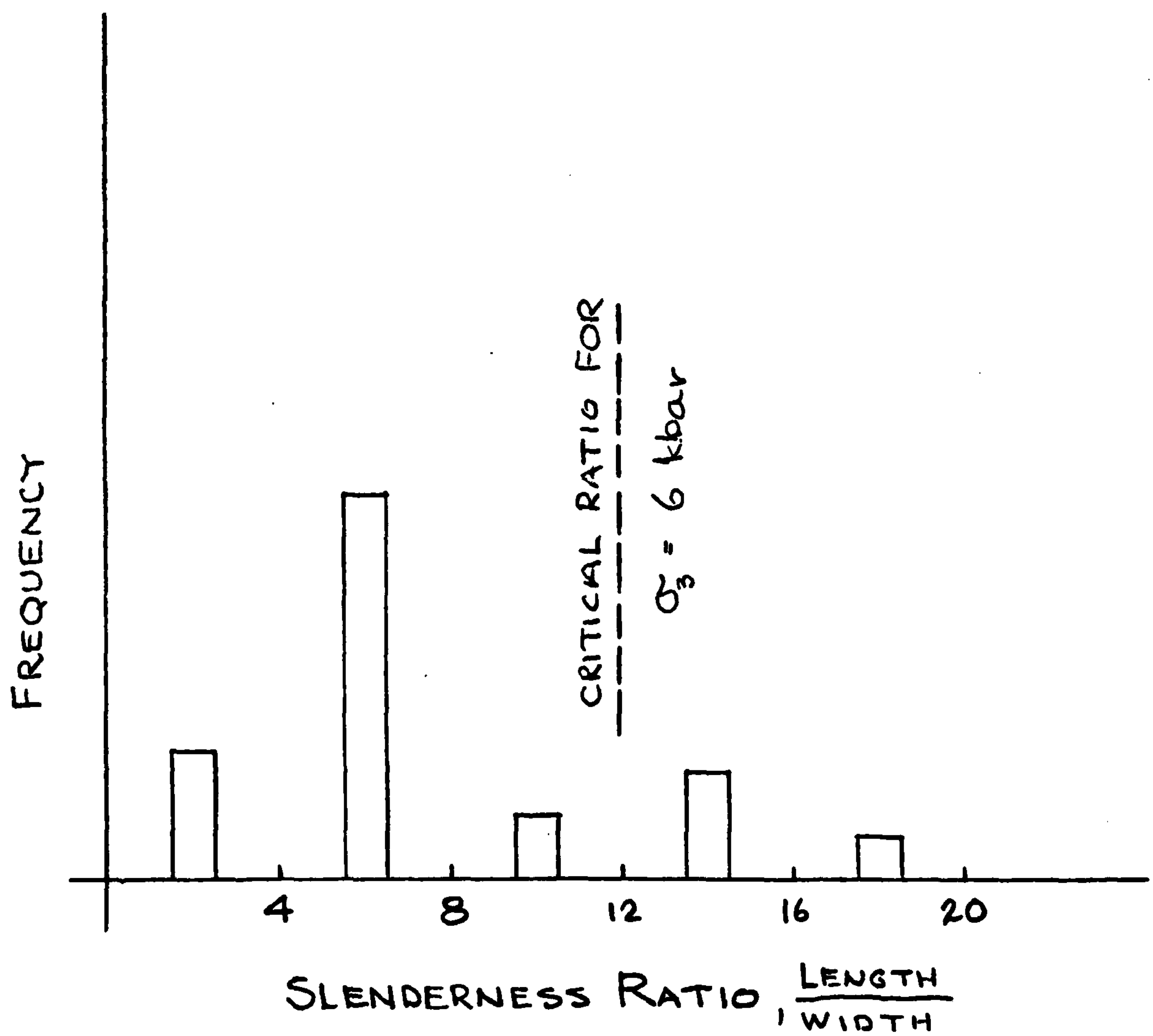
11/1/75 WFBRACE MIT

the cause of the sudden instability so common in brittle rocks and as yet unexplained. One test of this idea is provided by observations of the slenderness ratio of these columns. This ratio, length divided by width, determines the axial stress at which the column collapses. As shown on the accompanying Figure 2, this ratio would be around 12 at the observed fracture stress of Westerly granite at 500 bars pressure. In the figure we show a histogram of measured slenderness ratios determined from samples recovered close to peak stress and sectioned for the SEM. It is seen that although most of the columns observed are stable at the stress applied, some have reached and even exceeded the critical ratio. Thus there would appear to be some merit in this idea, and we will in the future consider more critical tests that might be made.

(3) Theoretical Studies

Our previous analysis [Walsh, 1975] of the gravity anomaly associated with faulting and dilatation has been found to be incorrect. The mistake arose because of the necessity of defining the coordinate system. The source of the error was subtle, and most of the effort on this problem during the past period was devoted to uncovering it. Because of the error, however, the analysis in the article is wrong.

The problem which we attempted to solve remains unanswered: how does deformation of the earth affect gravity measurements? The correct expression for the gravity change due to deformation, although simpler than my incorrect equation, appears to be more difficult to evaluate. We are currently trying to use this



FREQUENCY
CRITICAL RATIO FOR
σ_3 = 6 kbar
4
8
12
16
20
SLENDERNESS RATIO, LENGTH / WIDTH

FIG 2.

expression to calculate the effect for a simple deformation source.

(4) Publications

The following three papers have either appeared or have been taken through the review stage and are currently in press. Copies are included.

Tapponnier, P., and W.F. Brace, Development of stress-induced microcracks in Westerly granite, Int. J. Rock Mech. Min. Sci., 13, 1-10, 1976.

Hadley, K., Comparison of calculated and observed crack densities and seismic velocities in Westerly granite, J. Geophys. Res., in press, 1976.

Brace, W.F., Direct observation of dilatant voids in rock, ASME, Appl. Mechan. Div., Vol. 16., in press, 1976.

W F Brace

W.F. Brace

References

Walsh, J.B., An analysis of local changes in gravity due to deformation, PAGEOPH, 113, 97-106, 1975.